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# Improving Coalbed Methane Recovery Ratio by Injecting Hot Carbon Bioxide

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Development and utilization of coalbed methane (CBM) is of great significance in adjusting the energy structure in China, reducing greenhouse gas emissions, improving the work conditions and mitigating the gas disasters of coal mines. However, the CBM reservoirs in China were mainly characterized with low gas saturation, low porosity, low permeability and low reservoir pressure which resulting in the difficulties of CBM exploitation.

Here we provide a method to enhance CBM (E-CBM) recovery ratio by injecting heat carbon dioxide ($CO_2$) into coal seams. This technology will effectively overcome the negative influence caused by the characters of low permeability, low pressure and low saturation of coal seams in China. The implementation steps are described as follows.

(1) After the implementation of multi-branches horizontal well, drain the gas well, decrease the reservoir pressure and recovery the CBM until the yield decrease to the industrial gas flow standard.

(2) Inject hot $CO_2$ into the borehole. Here the temperature of $CO_2$ varies from 180℃ to 220℃ and the injection pressure should be not more than 5 MPa.

(3) Shut off the gas well for soaking.

(4) Drain the gas well and decrease the reservoir pressure.

(5) Produce the gas and separate $CO_2$ and CBM from the produced gas mixture.

(6) Repeat steps (2) ~ (5) until the output is lower than the industrial gas flow standard. Shut off the gas well.

The flow chart of enhancing CBM recovery rate by injecting hot $CO_2$ can also be interpreted as **Fig. 1**. The $CO_2$ mentioned in the step (2) can be obtained and purfied from natural gas field gas, ammonia byproduct gas, refining petroleum by-product gas, lime kiln exhaust gas or coal-fired boiler flue gas. The purified $CO_2$ can be heated through the combustion of the recovered and purified CBM from the gas well.

The principle of the novel idea could be explained as follows. First, under the conditions of 25℃ and equilibrium water, the isothermal adsorption experiments results of coal samples from No.3 coal seam of Jincheng area showed that the Langmuir constant $V_L$ (Langmuir volume) of $N_2$, $CH_4$ and $CO_2$ were 14.63cm$^3$/g, 34.58cm$^3$/g and 42.25g/cm$^3$, separately. Therefore, the adsorption capacity of coal to these three kinds of gas could be arranged in this order: $CO_2$ > $CH_4$ > $N_2$, separately. Second, the Langmuir pressure ($P_L$) were 2.14 MPa ($N_2$), 1.71 MPa ($CH_4$), 0.59 MPa ($CO_2$), separately, which

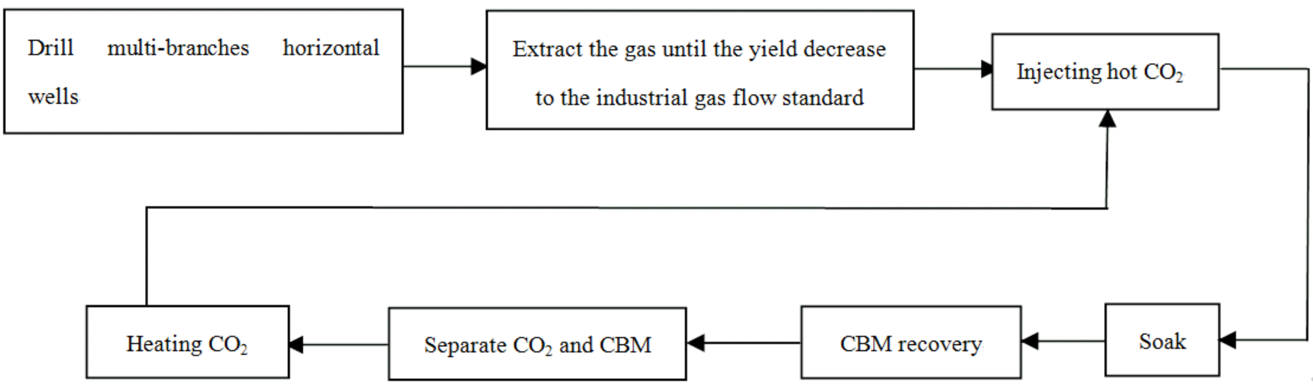


Fig. 1 Flow chart of enhancing CBM (E-CBM) recovery rate by injecting hot $CO_2$

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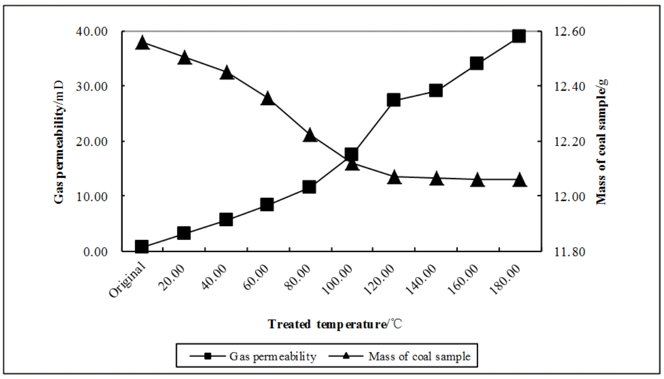


Fig. 2 The fluctuation of gas permeability of Jincheng No. 3 coal with the treated temperature

imply that the priority desorption of these three kinds of gas could be arranged in this order: $N_2$> $CH_4$> $CO_2$ (the greater $P_L$ value the more easily to desorb from the coal). In other words, the adsorption ability of $N_2$ to coal was lower than $CH_4$, and it was inferior in the adsorption competition with $CH_4$ while the adsorption ability of $CO_2$ to coal is higher than $CH_4$, and was prior in the competition with $CH_4$.

That is to say, $CO_2$ could compete with CBM in the coal adsorption process, and replace the $CH_4$ adsorped in the coal matrix. Furthermore, hot $CO_2$ would increase the free energy of adsorption state CBM, thus increase the desorption rate of CBM from the coal matrix, and at the same time, accelerate seepage flow due to the inflation when the gas was heated. Also, due to the dehydration of coal rock and the shrinkage of coal matrix and et al, the gas permeability of the heated coal samples could be increased (as shown in **Fig. 2**), and therefore the CBM would be accelerated into the borehole. In the end, injecting hot $CO_2$ into the coal seams could also be an effective method for $CO_2$ sequestration underground which would be helpful to the energy-saving and emission-reduction goal in China.

**Key words:** coalbed methane, recovery ratio, hot carbon bioxide, absorb, desorb, permeability